Renewable DG Assessment
Methodology and Approach

CEC PIER Program Meeting

September 14, 2004

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Agenda

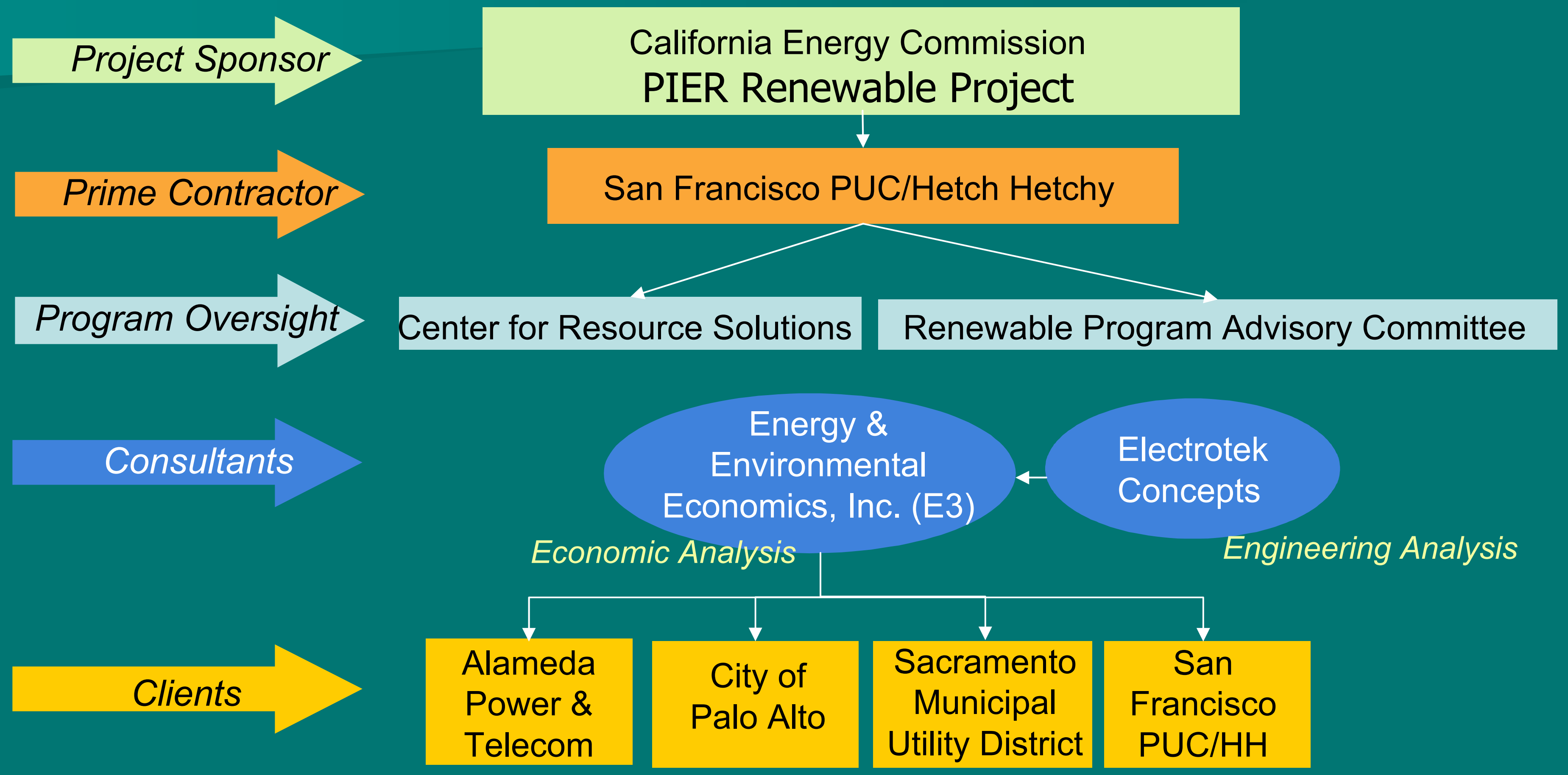
- Overview of Renewable DG Assessment Project
- RDG Evaluation Methodology
  - Economic Analysis
  - Engineering Analysis
- Applicability to California Renewable Resource Evaluation in other jurisdictions

Overview of Renewable DG Assessment Project

Project Objectives

- Develop economic and engineering screening methodology for renewable DG appropriate for municipal utility evaluations
- Methodology developed to:
  - Identify best locations and timing for renewable DG
  - Determine reliability impacts of renewable DG
  - Assess impact of uncertainty of load growth and technology performance

Project Organization



Project Status

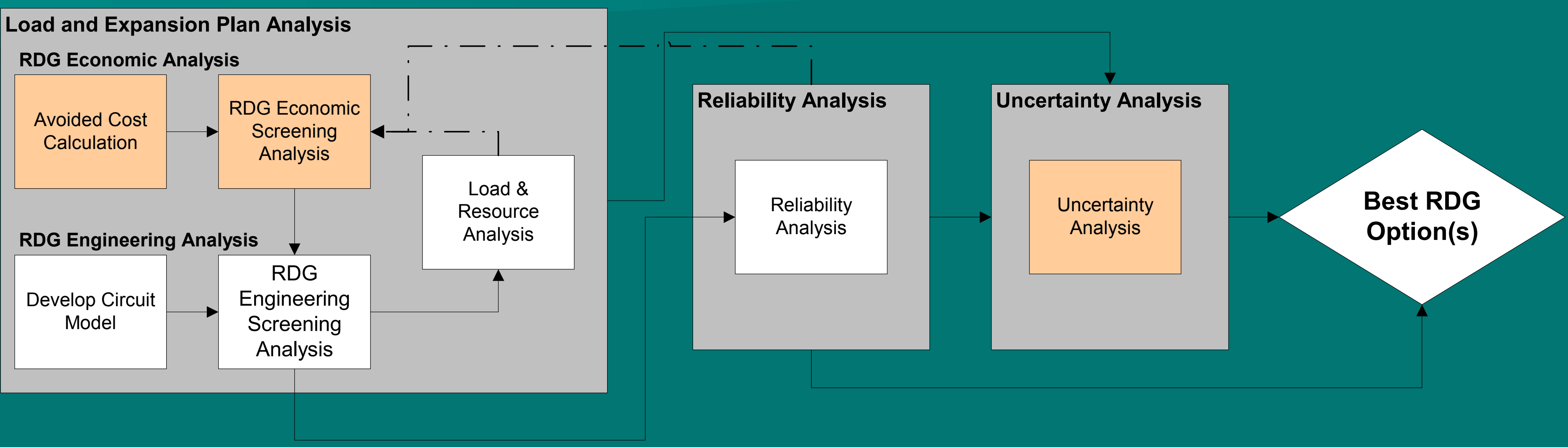
- RDG Assessment analysis and reporting completed for Alameda Power & Telecom and City of Palo Alto Utilities
- Analysis complete for Sacramento Municipal Utility District and reporting in progress
- Analysis 50% complete for San Francisco PUC/Hetch Hetchy
  - Analysis and reporting expected to be completed by September 30th

Key Results to Date

- Difficult to find cost-effective RDG on a net benefit basis
  - Avoided costs too low
  - RDG capital costs too high
- Indirect benefit value must be high
- Cost-effective technologies tended to be combined heat and power applications
- If sited in the best location RDG can provide substantial benefits to distribution systems with regard to:
  - Capacity release
  - Peak loss reduction

Renewable DG Evaluation Methodology

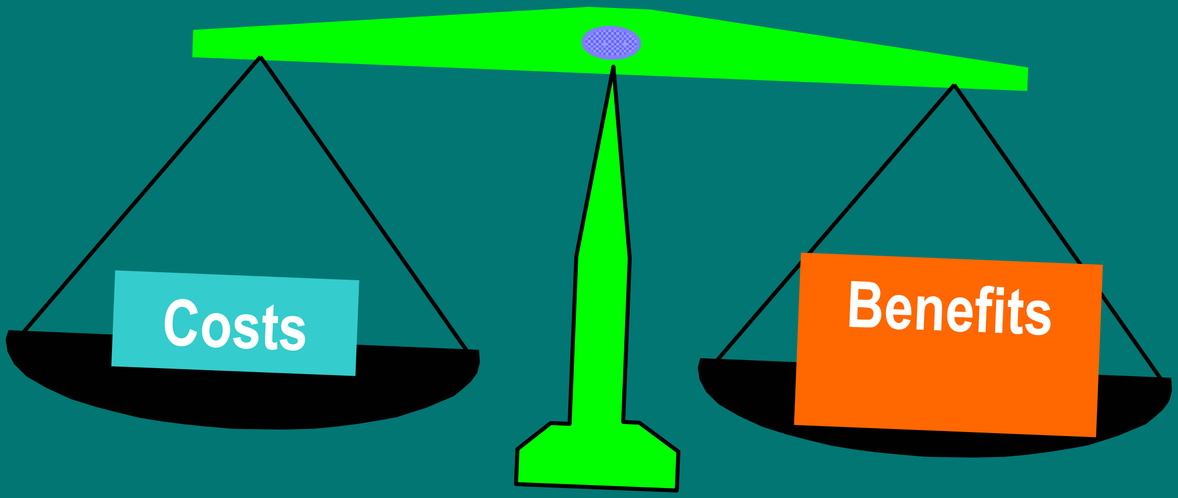
Evaluation Methodology: Economics



- Economic tools: E3 spreadsheet-based model

Economic Screening

- Economic screening analysis is based on lifecycle benefits from each stakeholder perspective
- Not a financial pro-forma model



Direct Benefits of Renewable DG

Benefit Category	Data Source/Analysis
Avoided Generation Costs	■ Internal market price forecast ■ Publicly available forecast of electricity or gas ■ E3 used the CEC natural gas price forecast as the foundation for our electricity price forecast
Avoided Distribution Costs	■ Marginal cost analysis of deferrable planned distribution investments
Avoided Transmission Costs	■ Marginal cost analysis of current and expected future transmission costs under MD02
Improved Reliability	■ Value of Service (VOS) analysis based upon calculated Energy Exceeding Normal (EEN)
Bill Savings for Customer	■ Rate analysis for each utility based on technology type and operation characteristics

Direct Costs of Renewable DG

Cost Category	Data Source/Analysis
Capital Costs	■ National Renewable Energy Laboratory Technology Characterizations ■ Direct Vendor Quotes
Operations & Maintenance Costs	■ National Renewable Energy Laboratory Technology Characterizations ■ Direct Vendor Quotes
Program Administration Costs	■ Vendor Estimates
Revenue Loss for Utility	■ Rate analysis for each utility based on technology type and operation characteristics

Cost Test Perspectives & B/C Ratios
Cost-effective to whom?

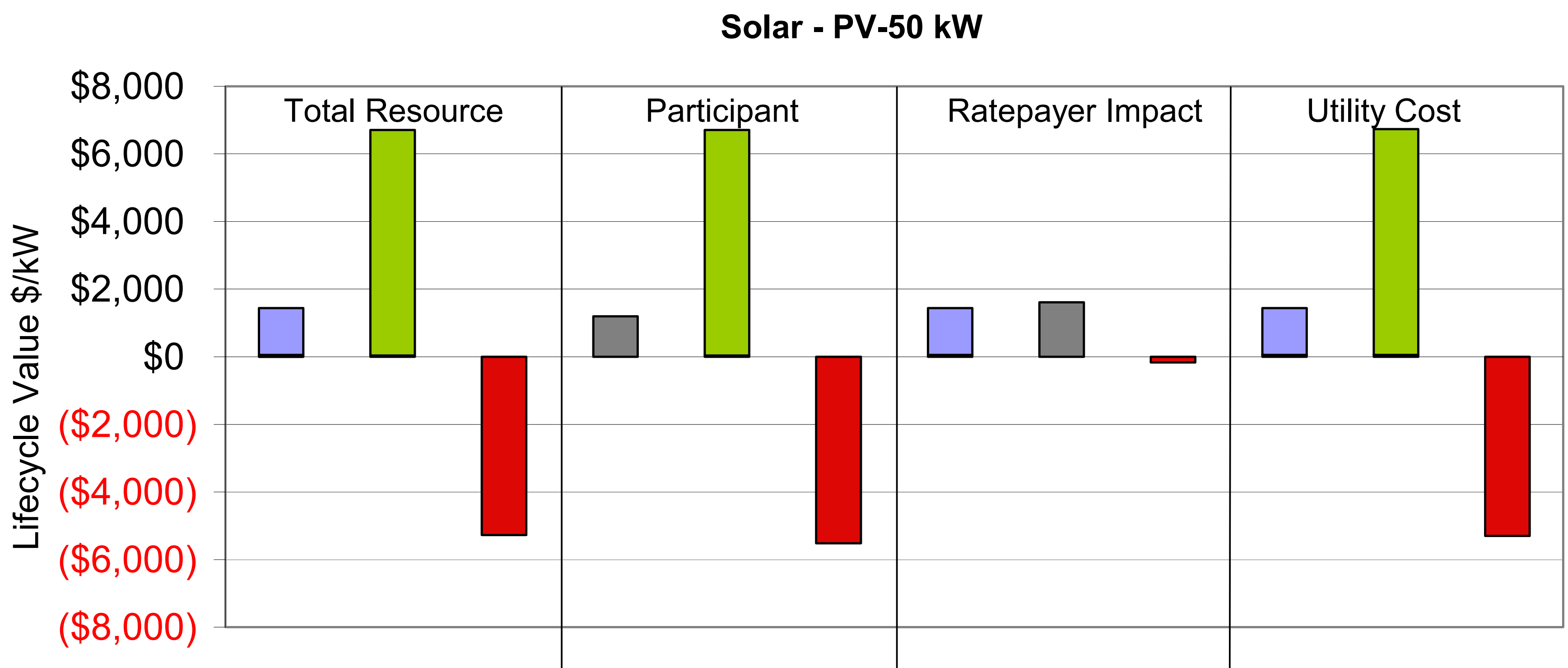
Calculate the net benefit of RDG technologies from several cost test perspectives

Cost Test Perspective	RIM – Ratepayer Impact Measure	PCT – Participant Cost Test/ Customer-Owned RDG	TRC – Total Resource Cost Test	UCT – Utility Cost Test
Benefits	Avoided costs (G, D,T)	Energy Savings Utility incentive	Avoided costs (G, D,T) Reliability Improvement	Avoided costs (G, D,T)
Costs	Revenue loss Utility incentive	RDG Capital, Fuel, and O&M Costs	RDG Capital , Fuel, and O&M Costs	RDG Capital , Fuel, and O&M Costs

Economic Model Summary Output

	TRC Cost Test	Participant (Customer or Merchant)	RIM Test (Customer Owned)	UCT Test (Utility Owned)
Biogas - 10kW PEM Fuel Cell	0.01	0.01	0.75	0.01
Biogas - 10kW PEM Fuel Cell CHP	0.39	0.44	0.73	0.33
Biogas - 100kW SOFC Fuel Cell	0.02	0.02	0.75	0.02
Biogas - 100kW SOFC Fuel Cell CHP	0.55	0.63	0.73	0.47
Biogas - 200kW PAFC Fuel Cell	0.01	0.02	0.75	0.01
Biogas - 200kW PAFC Fuel Cell CHP	0.48	0.55	0.73	0.41
Biogas - 200kW PEM Fuel Cell	0.02	0.02	0.75	0.02
Biogas - 200kW PEM Fuel Cell CHP	0.54	0.62	0.73	0.46
Biogas - 250kW MCFC Fuel Cell	0.01	0.01	0.75	0.01
Biogas - 250kW MCFC Fuel Cell CHP	0.40	0.46	0.73	0.34
Biogas - 30 kW Capstone 330 Microturbine	0.03	0.03	0.75	0.03
Biogas - 30 kW Capstone 330 Microturbine w/ CHP	0.65	0.74	0.73	0.54
Biogas - 500 kW Gas Recip GA-K-500	0.06	0.06	0.75	0.05
Biogas - 800kW Caterpillar G3516 LE	0.08	0.09	0.75	0.08
Biogas - 800kW Caterpillar G3516 LE w/CHP	**1.08**	**1.23**	0.73	0.86
Biogas - 3MW Caterpillar G3616 LE	0.09	0.09	0.75	0.08
Biogas - 3MW Caterpillar G3616 LE w/CHP	**1.10**	**1.26**	0.73	0.87
Biogas - 5MW Wartsila 5238 LN	0.74	0.85	0.73	0.57
Biogas - MSW Gassification	0.41	0.35		0.49
Biodiesel - 500kW DE-K-500	0.12	0.13	0.77	0.11
Solar - PV-5 kW	0.16	0.21	0.57	0.16
Solar - PV-50 kW	0.21	0.20	0.79	0.21
Solar - PV-100 kW	0.21	0.20	0.79	0.21
Solar - Thermal SAIC SunDish 25 kW	0.15	0.14		0.24
Wind - Bergey WD -10kW	0.13	0.15	0.70	0.13
Wind - GE 750 kW	0.91	0.91		**1.47**
Wind - GE 1.5 MW	**1.08**	**1.08**		**1.72**

Cost and Benefit by Perspective



	Total Resource			Participant			Ratepayer Impact			Utility Cost		
	Benefit	Cost	Net Benefit	Benefit	Cost	Net Benefit	Benefit	Cost	Net Benefit	Benefit	Cost	Net Benefit
Wholesale Energy	$1,383			$0			$1,383			$1,383		
Transmission Rate Savings	$50						$50			$50		
Distribution Capacity Savings	$0						$0			$0		
Improved Reliability (VOS)	$2											
Other Direct Benefits	$0			$0			$0					
Municipal Utility Incentives				$0				$0				
Utility Revenue Change				$1,194				$1,609				
DG Capital Costs		$6,675			$6,675						$6,675	
DG Fuel Costs		$0			$0						$0	
DG Fixed O&M		$36			$36						$57	
DG Variable O&M		$0			$0						$0	
Non Municipal Incentives	$0			$0								
Net Benefit			($5,276)			($5,517)			($175)			($5,298)

Assessment of the 'Shortfall' Between Benefits & Costs

DIRECT BENEFITS:

•Energy Generation

•Transmission Savings

•Distribution Capacity Savings

Less

COSTS:

Capital Costs

O&M Costs

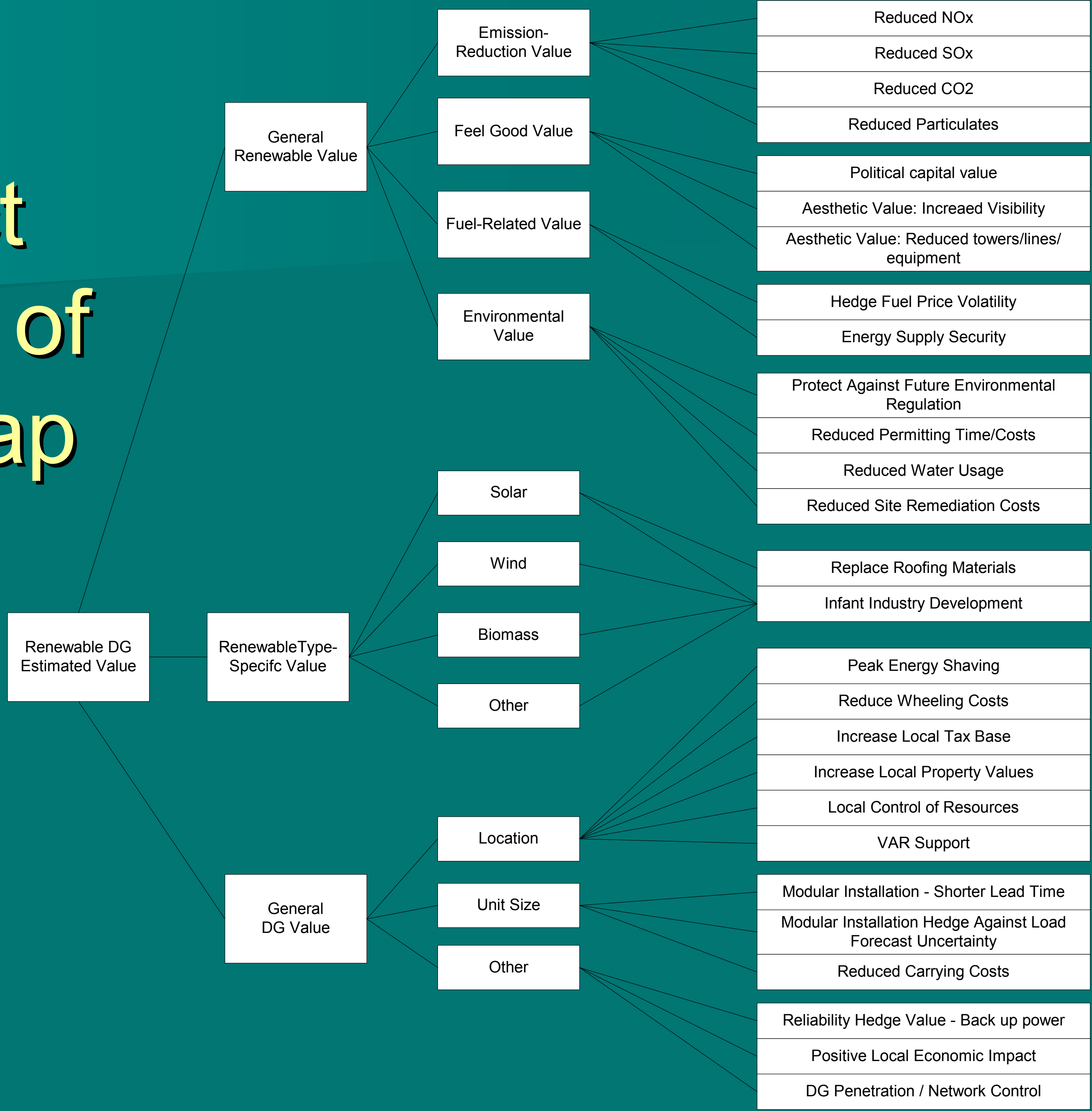
Program Administration Costs

Equals

SHORTFALL

"INDIRECT" BENEFITS MAY BE GREATER THAN THE SHORTFALL

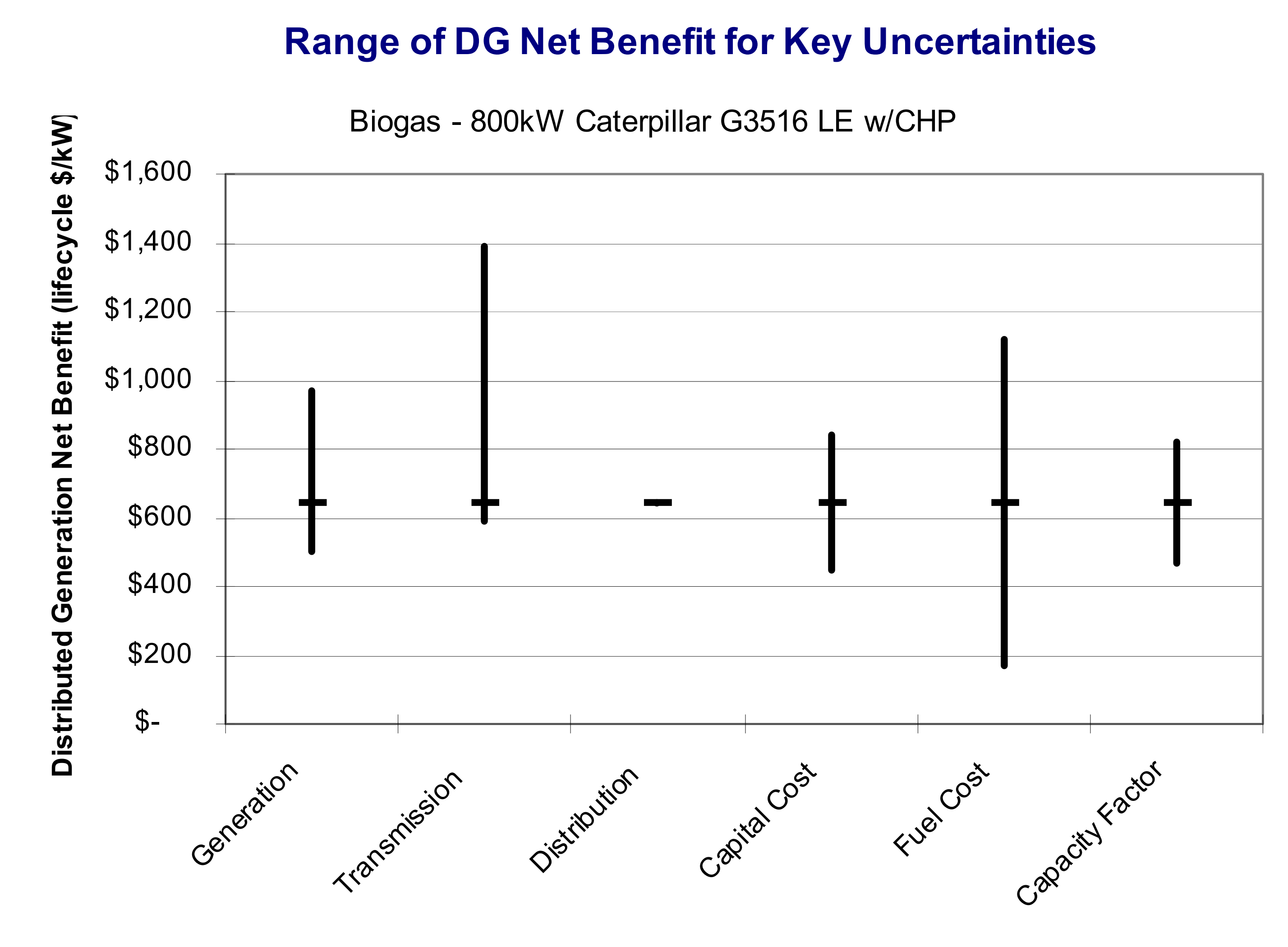
Indirect Benefits of RDG Map



Uncertainty Analysis

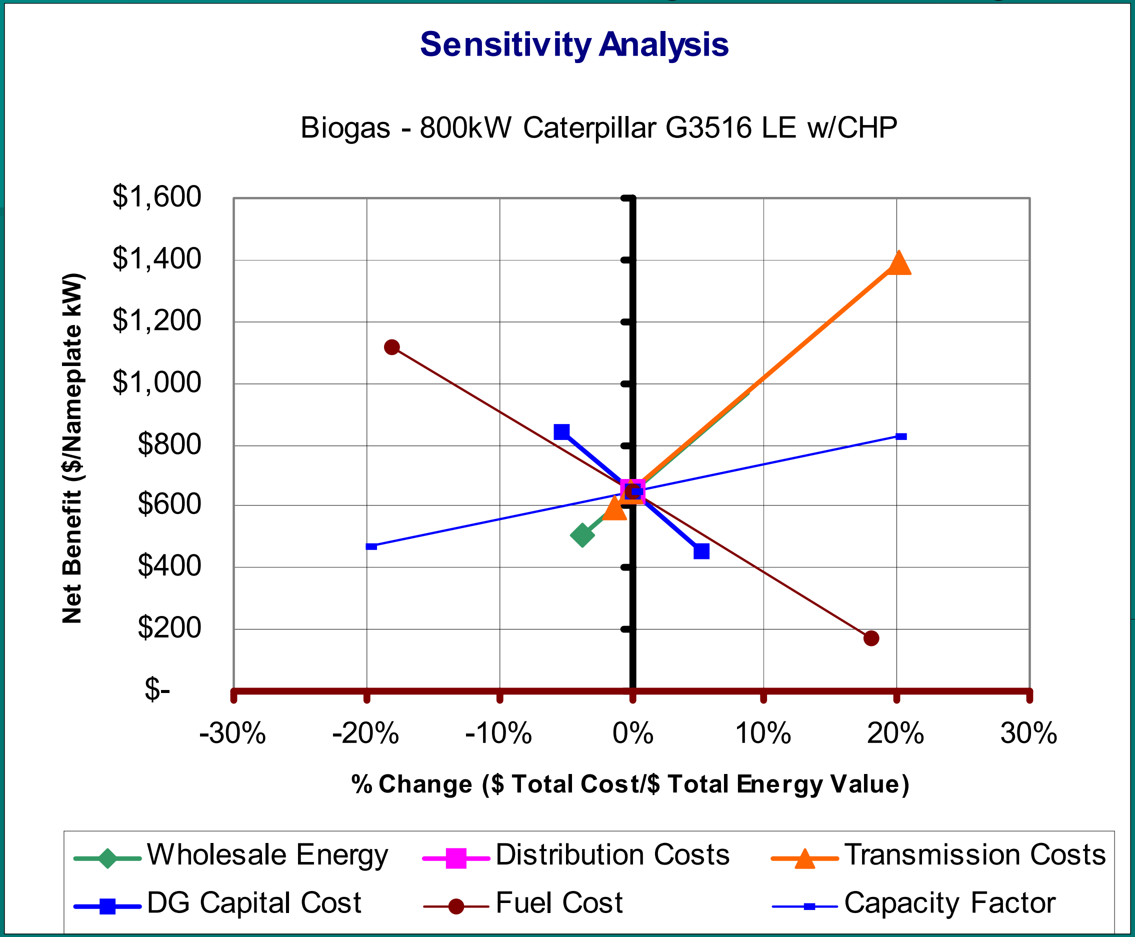
- Economic screening analysis results can change dramatically due to uncertainty
- Particularly true for intermittent resources
- Key uncertainty variables
  - DG output pattern
  - Load forecast
  - Technology performance
  - Wholesale energy costs
  - Transmission costs

Testing Sensitivity of Results for Uncertainty



City of Palo Alto Utilities: 8-2004 Analysis

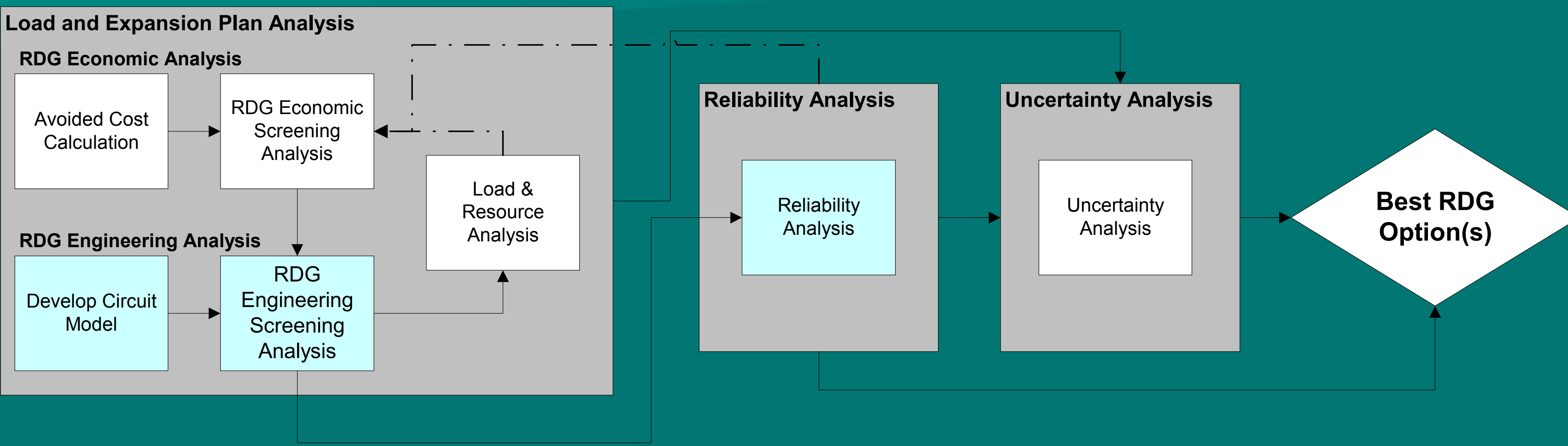
Detailed Sensitivity Analysis Result



City of Palo Alto Utilities: 8-2004 Analysis

The 800 kW biogas generator with CHP (combined heat and power) is cost-effective under the TRC test within nearly the full range of sensitivities tested

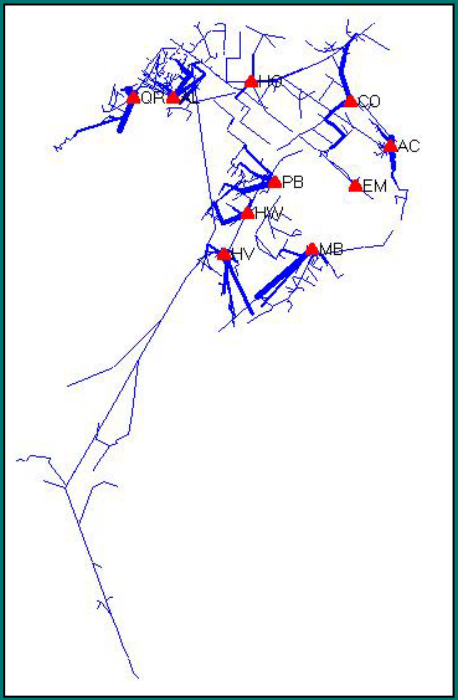
Evaluation Methodology: Engineering

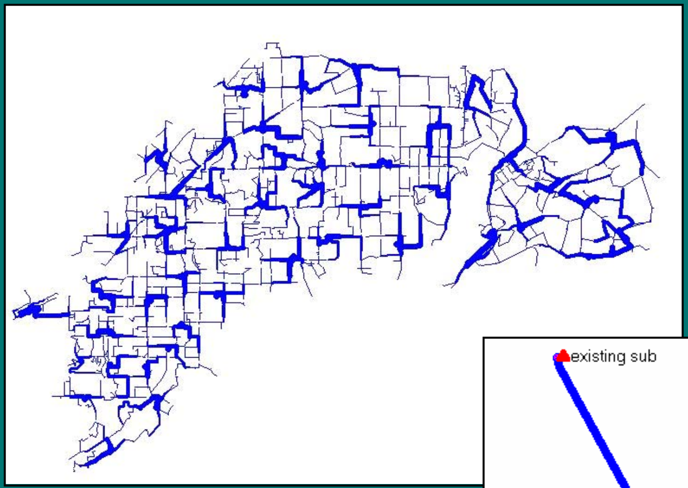


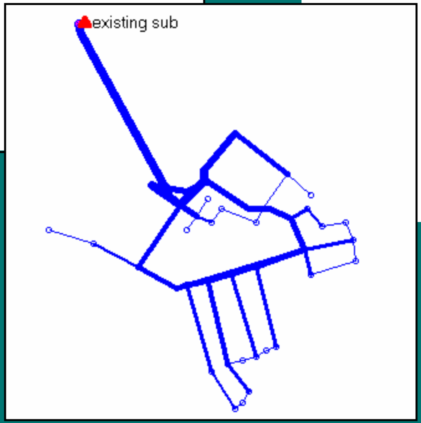
- Engineering tools: Electrotek's Distribution System Simulator (DSS)

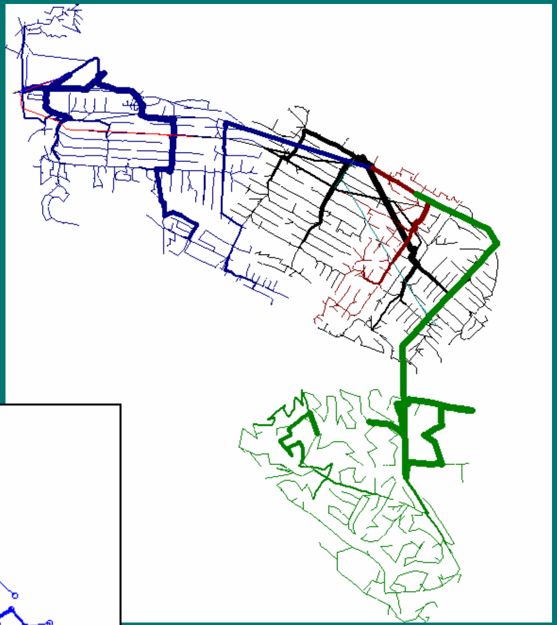
Develop Circuit Model

- Identify timing and location of future capacity constraints
- Typical model is a ‘snap shot’ of peak hour of the year
- Hourly load-flow capability creates link to planning decisions (e.g. DG dispatch requirements)



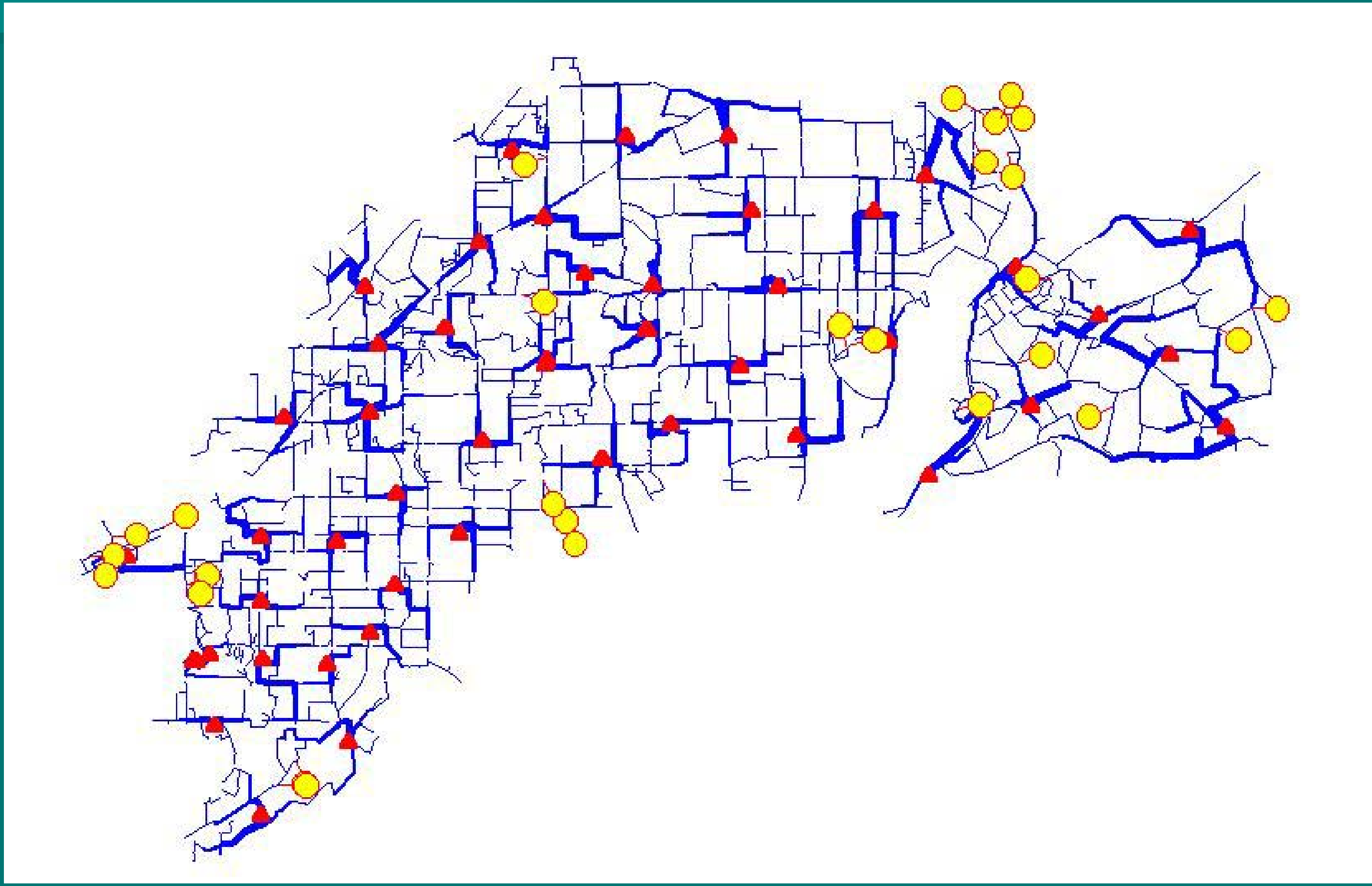






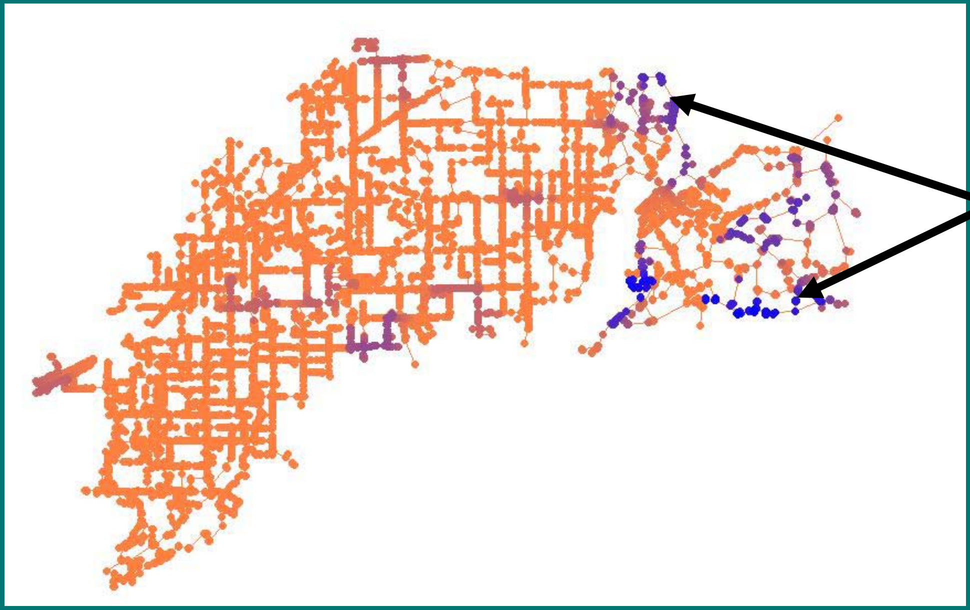
Siting Analysis

SMUD Example: 13.5 MW DG optimally sited for released capacity



Operational Feasibility

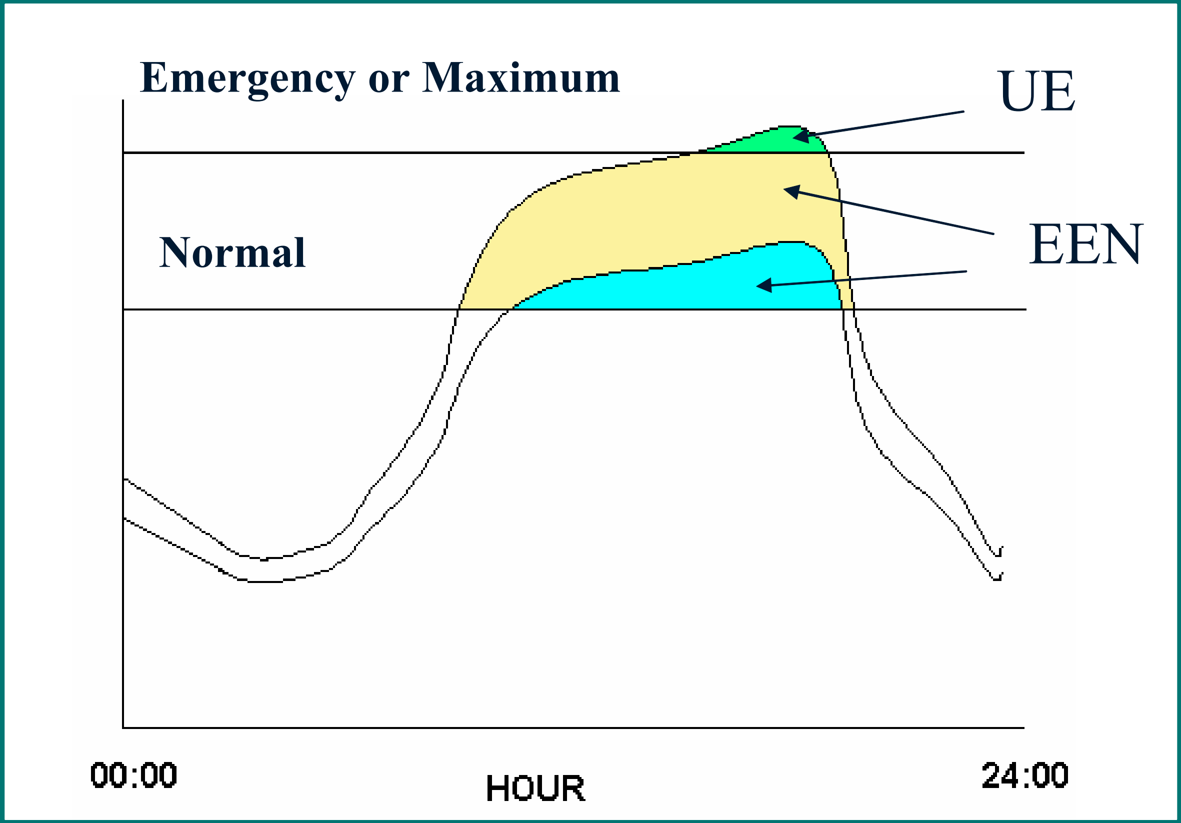
- Voltage Regulation Screen
  - Using a voltage change threshold of 5%
- Overcurrent Protection Screen
  - Typically evaluated with a fault current change threshold of 50%



Darker colors indicate greater changes in fault current with RDG installed

Reliability Analysis-Basic Concept

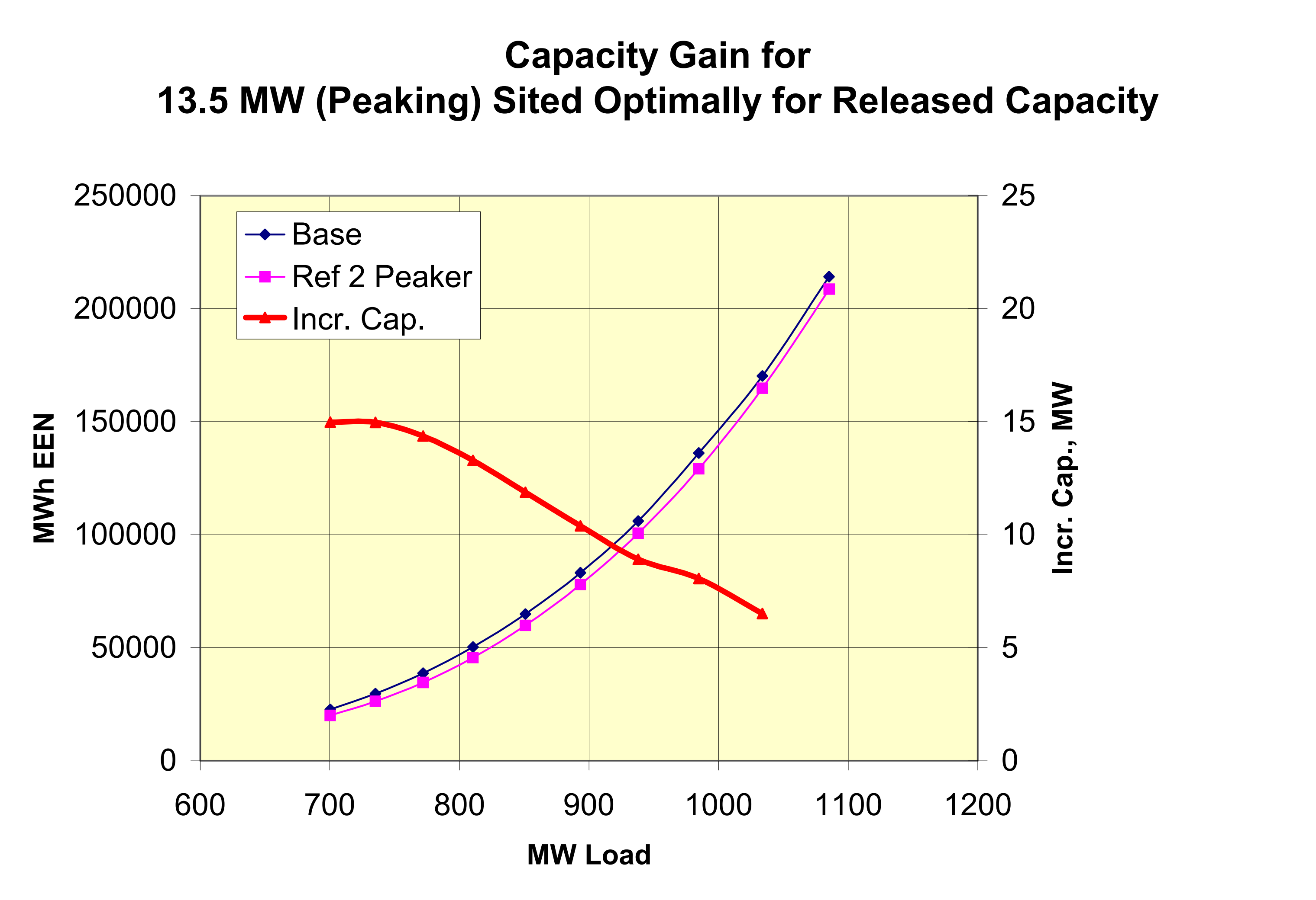
- Hourly load-flow example for a peak day



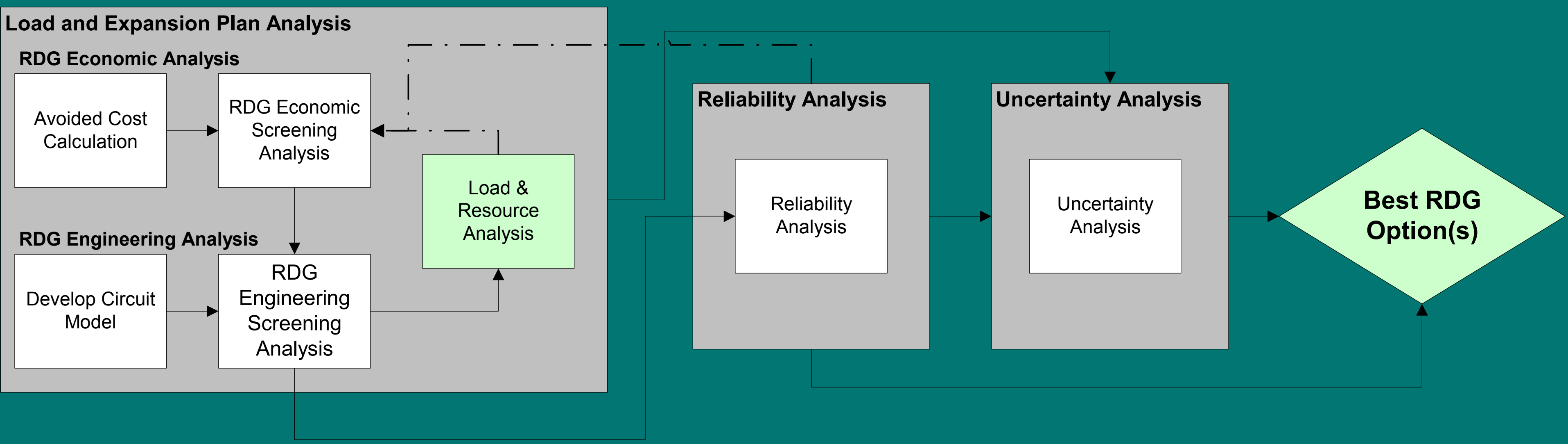
UE = Unserved Energy, EEN = Energy Exceeding Normal

- Calculate UE and EEN with renewable DG operating
- Allows quantification and costing of reliability benefits

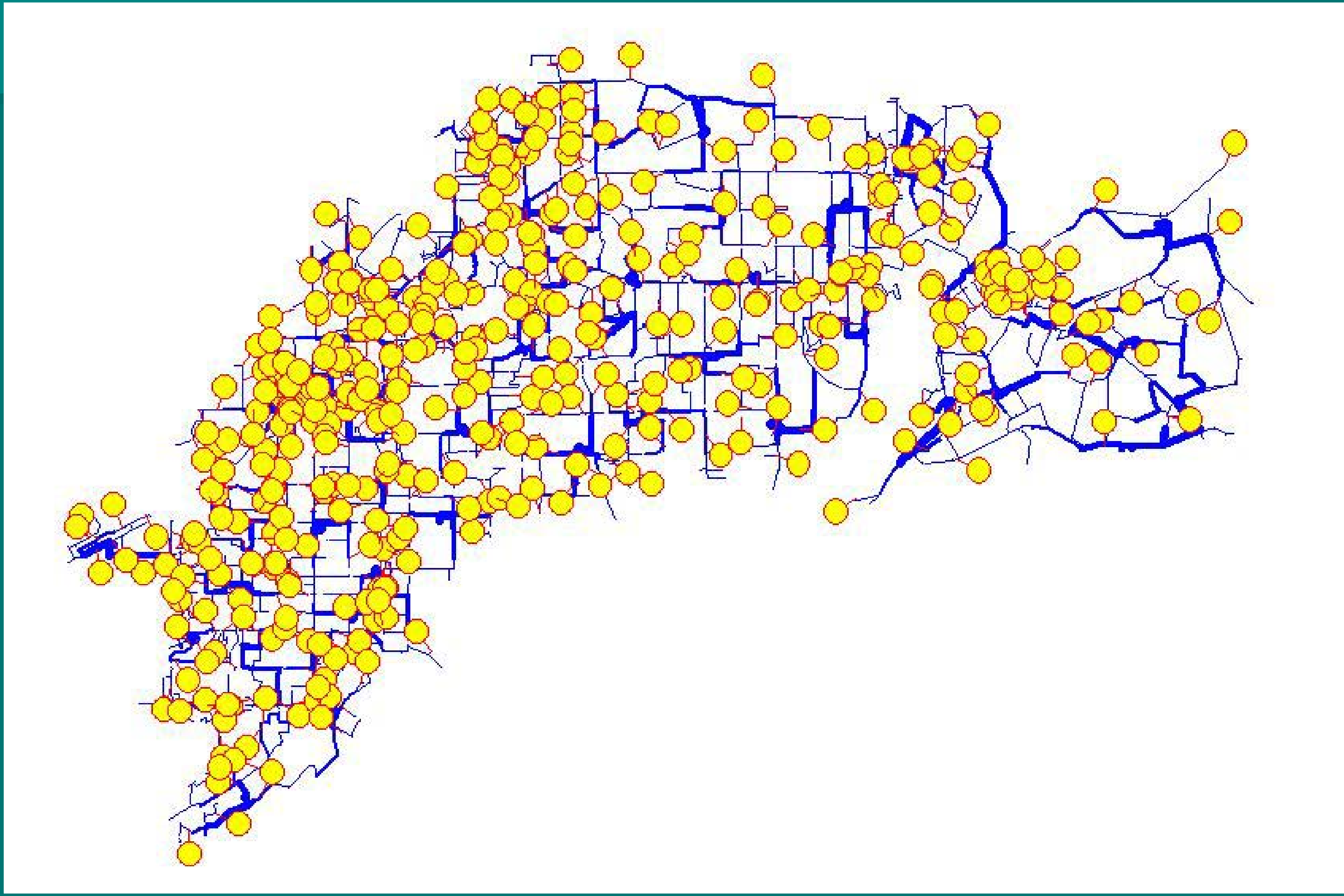
EEN computed for 13.5 MW of DG sited in 500 kW units for maximum benefit to released capacity (peaking)



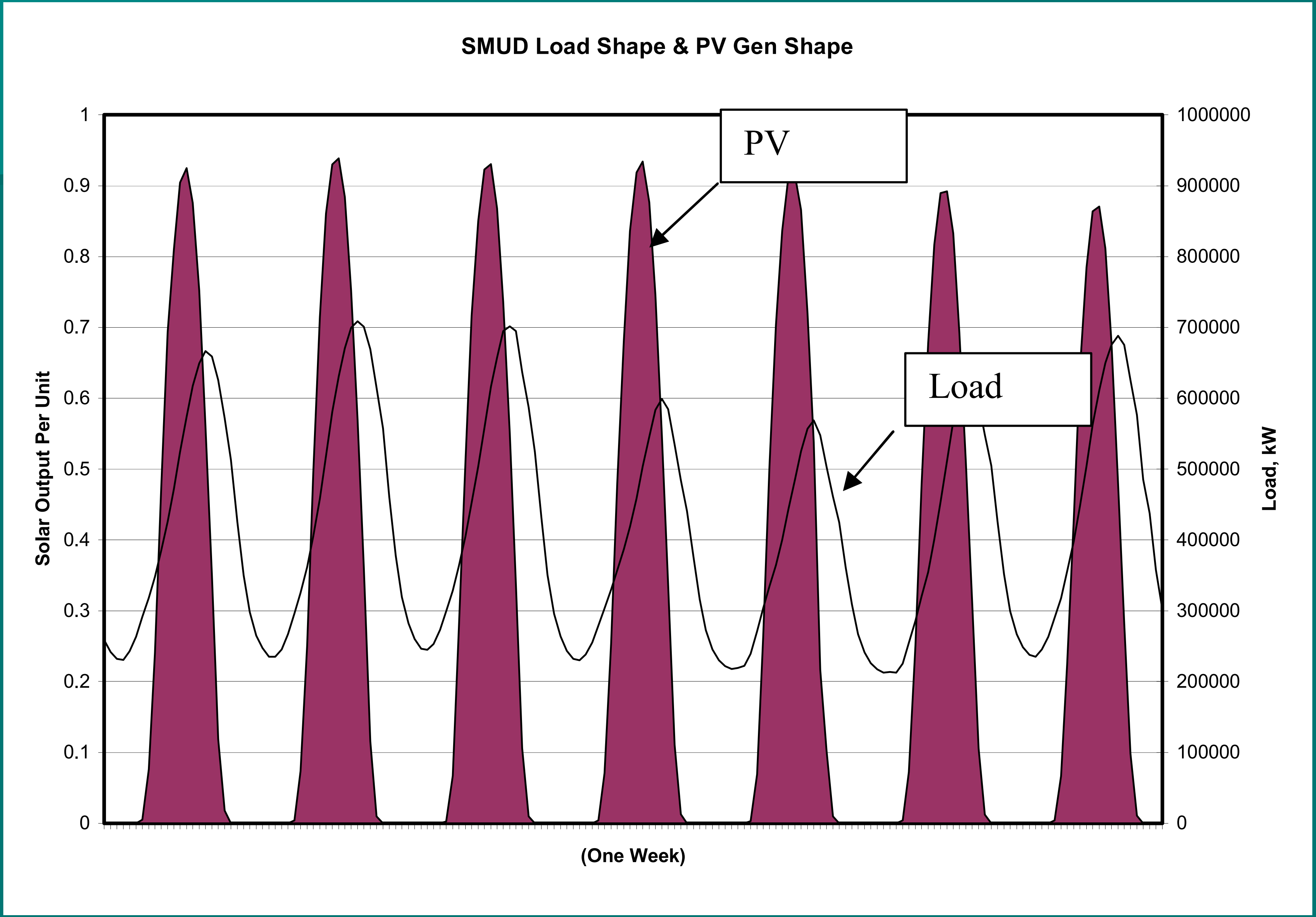
Evaluation Methodology Combined Economic & Engineering



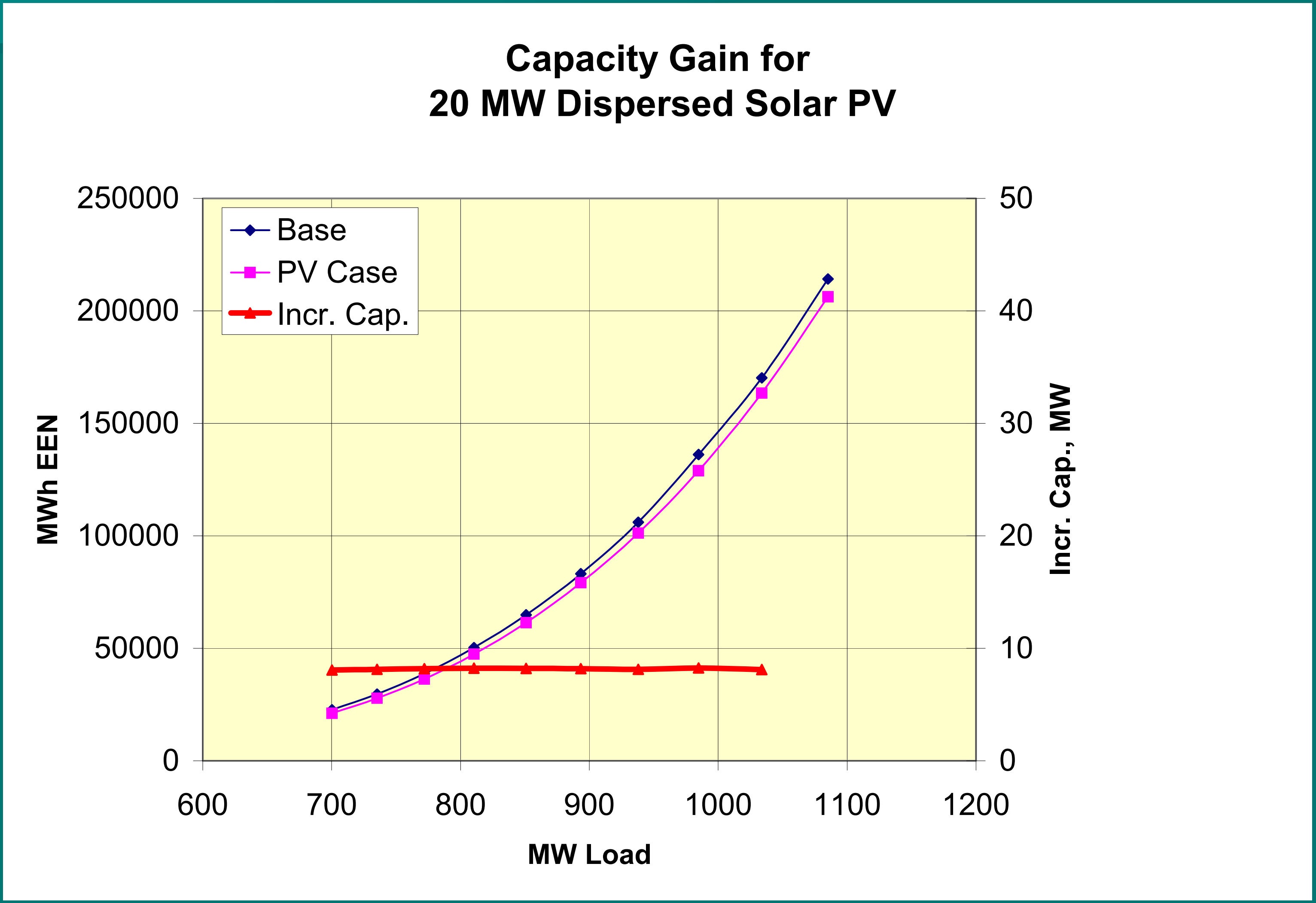
Case 4: 20 MW of Distributed PV



SMUD Load Shape & PV Generation Shape



Capacity gain with respect to EEN for 20 MW of solar PV



Conclusions

- Economic tools have been developed
  - We should be able to find cost-effective DG
- Local engineering tools have been developed
  - We should be able to put it in the right place
- Short-term Success
  - Four municipal utility case studies
- Long-term Success?
  - We want to find renewable DG applications that get built